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WEATHER AND CIRCULATION OF JULY 1971

A Midmonth Circulation Reversal Accompanied by Drought-Relieving Rains in Texas

A. JAMES WAGNER

National Meteorological Center, National Weather Service, NOAA, Suitland, Md.

1. MONTHLY MEAN CIRCULATION

July was characterized by a considerable reduction in the strength of high-latitude blocking that had reached a peak during June. The Western Hemisphere polar zonal index, a measure of the strength of the westerlies in the latitude band between 55° and 70°N, increased from −0.3 m/s (2.7 m/s below normal) in June to +2.1 m/s (0.8 m/s below normal) in July. The major portion of the block retrograded to northeast Siberia, where a 700-mb High with a 52-m positive anomaly center was found (figs. 1, 2). Heights fell by more than 30 m over a large portion of the polar area, with greatest falls of 85 m near Spitzbergen (fig. 3).

As storms deepened south of the Siberian block and moved to the western Aleutians with greater than normal intensity for the season, the midlatitude portion of the Pacific ridge was thrust eastward into the Gulf of Alaska where it joined with the remains of the June blocking in northwest Canada. The largest height anomaly change from June to July in the Western half of the Northern Hemisphere was centered near 50°N, 140°W where an increase of 101 m was observed (fig. 3).

Amplification of the planetary wave train downstream from the strengthened western North American ridge, which was 47 m above normal, resulted in deepening to as much as 72 m below normal of a full-latitude trough extending from the eastern shore of Hudson Bay to the southern Appalachian Mountains and strengthening of the Bermuda High (figs. 1, 2, 3). Heights also rose strongly across Europe and northern Russia, with maximum June to July increases of 92 m over the British Isles and 106 m near the Ural Mountains (fig. 3).

The Northern Hemisphere 700-mb jet stream averaged

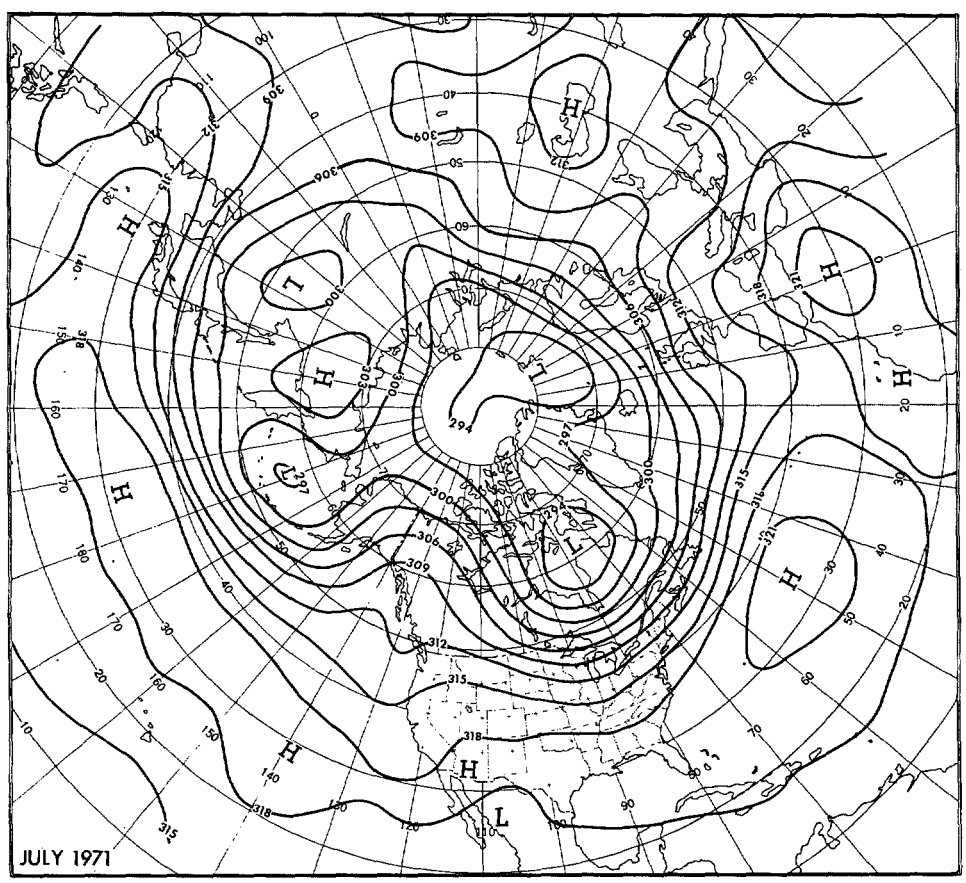

FIGURE 1.—Mean 700-mb contours in dekameters (dam) for July 1971.

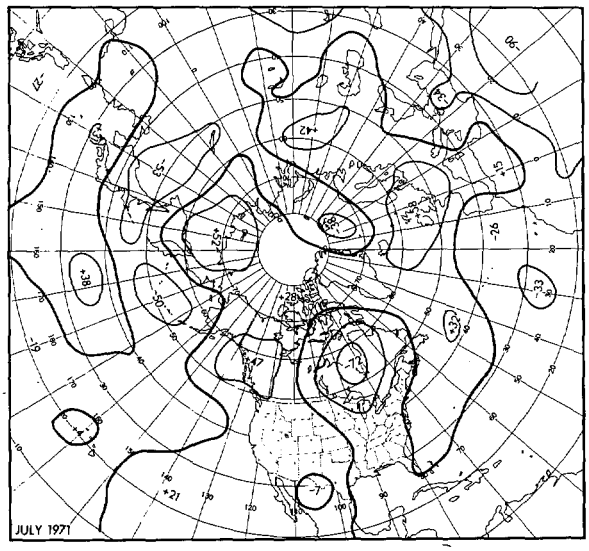

FIGURE 2.—Departure from normal of mean 700-mb height (m) for July 1971.

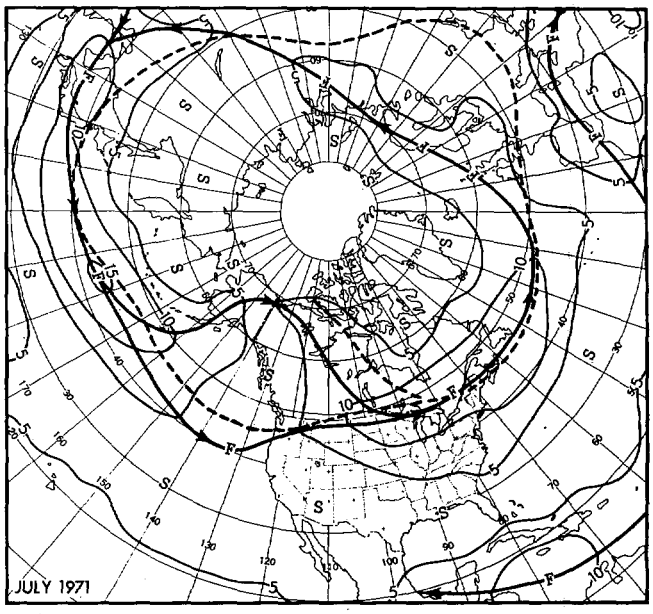

FIGURE 4.—Mean 700-mb geostrophic wind speed (m/s) for July 1971. Solid arrows show the observed axes of maximum wind speed, and dashed lines show the normal July positions.

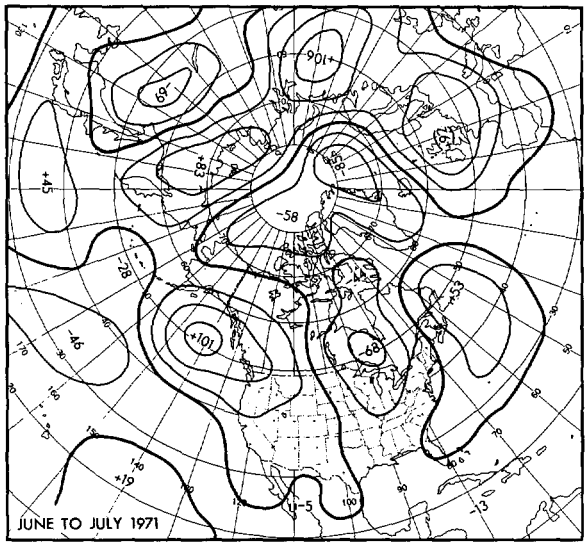

FIGURE 3.—Mean 700-mb height anomaly change (m) from June to July 1971.

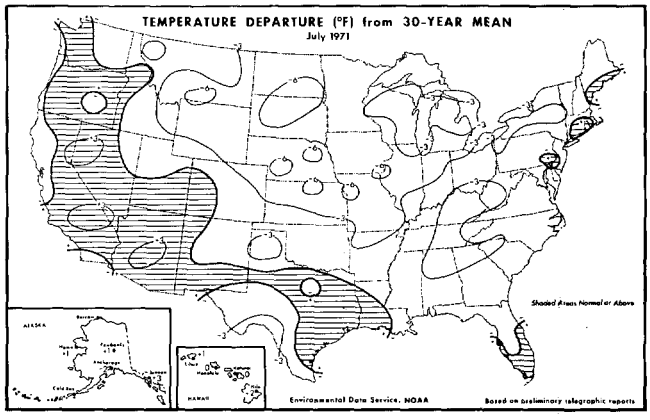

FIGURE 5.—Departure from normal of average surface temperature (°F) for July 1971 (from Environmental Data Service and Statistical Reporting Service 1971).

close to its normal July position over all areas except Eurasia, where a strong ridge deflected storms along a track just north of Scandinavia (fig. 4). The axis of maximum winds was most pronounced from the east coast of Asia to the central Pacific, where mean wind speeds were 7 to 8 m/s above normal. Downstream from this area, the jet split into two axes, one looping northward through Alaska and northwest Canada, and the other curving slightly southward and then crossing the Oregon coast into the northern United States. This lower latitude branch of the jet was active only during the first part of July, and marked the end of a regime which had persisted for several months (Stark 1971, Posey 1971).

2. MONTHLY TEMPERATURE

Except for portions of the Southwest and Great Basin, July mean temperatures averaged below normal over most of the conterminous United States (fig. 5). This represented a marked reversal from June, when temperatures averaged above normal over most of the country except the Northwest and Southwest (fig. 5 of Posey 1971). The temperature at only 52 of 100 stations remained within one class out of five going from June to July. According to Namias (1952), summer is ordinarily one of the most persistent times of year, and the average number of stations remaining within one temperature class from June to July in his sample from the 1940s was 70. As will be seen later in more detail, the weather and circulation of the last half of July gave the month its predominant character; the June regime continued for about the first third of the month.

Even though the relatively low-temperature regime was established for only a little more than the last half of the month, many areas in the northern and central portion of the Nation averaged more than 6°F below

TABLE 1.—*Record and near-record monthly mean temperatures established during July 1971*

Station	Temperature (°F)	Anomaly (°F)	Remarks
Waterloo, Iowa	66.4	−7.4	Coolest July on record
Fargo, N. Dak.	65.1	−6.3	Coolest July since 1904
Springfield, Ill.	72.4	−5.6	Coolest July since 1891 and 2d coolest on record
Huron, S. Dak.	69.4	−5.6	2d coolest July since 1915
Bismarck, N. Dak.	66.2	−5.5	Coolest July since 1915
Helena, Mont.	63.2	−5.2	3d coolest July on record
Dubuque, Iowa	68.0	−4.6	Coolest July on record
St. Cloud, Minn.	66.6	−4.4	2d coolest July on record
Erie, Pa.	66.9	−4.2	2d coolest July on record
Albany, N.Y.	68.4	−3.7	2d coolest July on record and coolest since 1860
Rockford, Ill.	70.7	−3.5	July averaged 3.5°F cooler than June; largest cooling from June to July in 65-yr record
Minneapolis, Minn.	68.8	−3.5	Tied 2d coolest July since 1931
Winslow, Ariz.	82.5	+2.3	Warmest July on record
Rapid City, S. Dak.	52.7	—	Lowest average July minimum on record
Milford, Utah	95.5	—	2d highest average July maximum on record

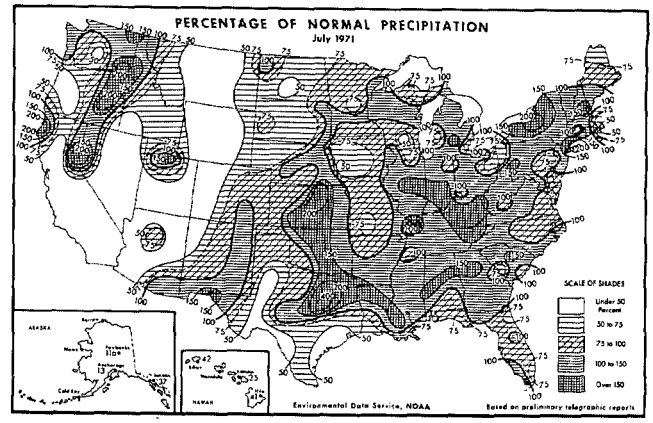

FIGURE 6.—Percentage of normal precipitation for July 1971 (from Environmental Data Service and Statistical Reporting Service 1971).

normal for the month as a whole. Several stations in the North Central States and even as far east as Albany, N.Y., reported record or near-record low July mean temperatures (table 1). At Rockford, Ill., July temperatures were actually 3.5°F lower than June's near-record warmth (Posey 1971). This was the greatest cooling from June to July ever observed at that station. The large monthly height falls north of the Great Lakes and increasing flow from the northwest (figs. 1, 3) were the principal reasons for the strong cooling over most of the eastern two-thirds of the country.

3. MONTHLY PRECIPITATION

As is frequently the case, especially in summer, the monthly precipitation distribution was only loosely related to the height anomaly pattern. In general, the eastern half of the Nation, where the flow was predominately cyclonic, was wetter than normal, while the western half, which had above-normal heights and mainly anticyclonic conditions, was mostly on the dry side (figs. 1, 2, 6). Even though parts of the West reported precipitation in excess of twice normal, the actual monthly totals in these areas of normal summer dryness were mostly less than 1 in. A few stations in the Rocky Mountains and the Southwest reported record and near-record long periods of deficient precipation continuing through July (table 2).

A report of 9.50 in. of precipitation during July (0.42 in. above normal) from Fort Myers, Fla., provided further welcome evidence that the Florida drought was on the wane. July ended 13 consecutive months of below-normal rainfall at Fort Myers.

Substantial rainfall in July brought welcome relief to the drought-stricken areas of central Texas and portions of New Mexico and southeastern Arizona (fig. 6). The drought in the Rio Grande Valley had been eased the previous month (Posey 1971), although only about half the normal July precipitation fell in that area (fig. 6). Most of the rain in Texas fell during the last 2 weeks of

TABLE 2.—*Record and near-record monthly and cumulative (in parentheses) precipitation totals established during July 1971*

Station	Amount (in.)	Anomaly (in.)	Remarks
Port Arthur, Tex.	4.31	−1.69	9th consecutive month with below-normal rainfall
Casper, Wyo.	0.11	−0.89	Driest July on record
Phoenix, Ariz.	0.24	−0.53	10th consecutive month with below-normal rainfall
Billings, Mont.	0.40	−0.50	
	(1.10)	—	2d driest June-July on record
Grand Junction, Colo.	0.15	—	
	(2.04)	−0.42	Driest first 7 mo of yr since 1900
Concordia, Kans.	10.17	+7.34	Wettest July on record
Columbus, Ga.	13.24	+7.37	Wettest month on official airport records beginning 1946
Bridgeport, Conn.	12.84	+9.07	Wettest month on record

the month, when the southern portions of some of the amplified troughs which deepened into the middle of the country were left behind as weak cutoff Lows whenever the westerlies increased at midlatitudes, shearing off the the northern portions of the troughs.

Three stations in widely scattered locations reported their wettest Julys and at two of these it was also the wettest month on record (table 2). The large monthly totals at these stations were contributed to by excessively heavy and prolonged or recurrent convective rains and slow-moving frontal systems.

4. VARIABILITY WITHIN THE MONTH

The first third of July had circulation and temperature regimes similar to those of June. Generally flat, fast westerly flow prevailed across the northern United States while a persistent trough remained deeper than normal off the Pacific coast (figs. 7A, 7B). Heights were slightly above normal over most of the conterminous United States, and below normal over all but the northwestern corner of Canada. A strong center of cyclonic activity (84 m below normal at 700 mb) was located east of Kamchatka, and another belt of storminess prevailed across the North Atlantic south of deeper than normal 700-mb Lows off the

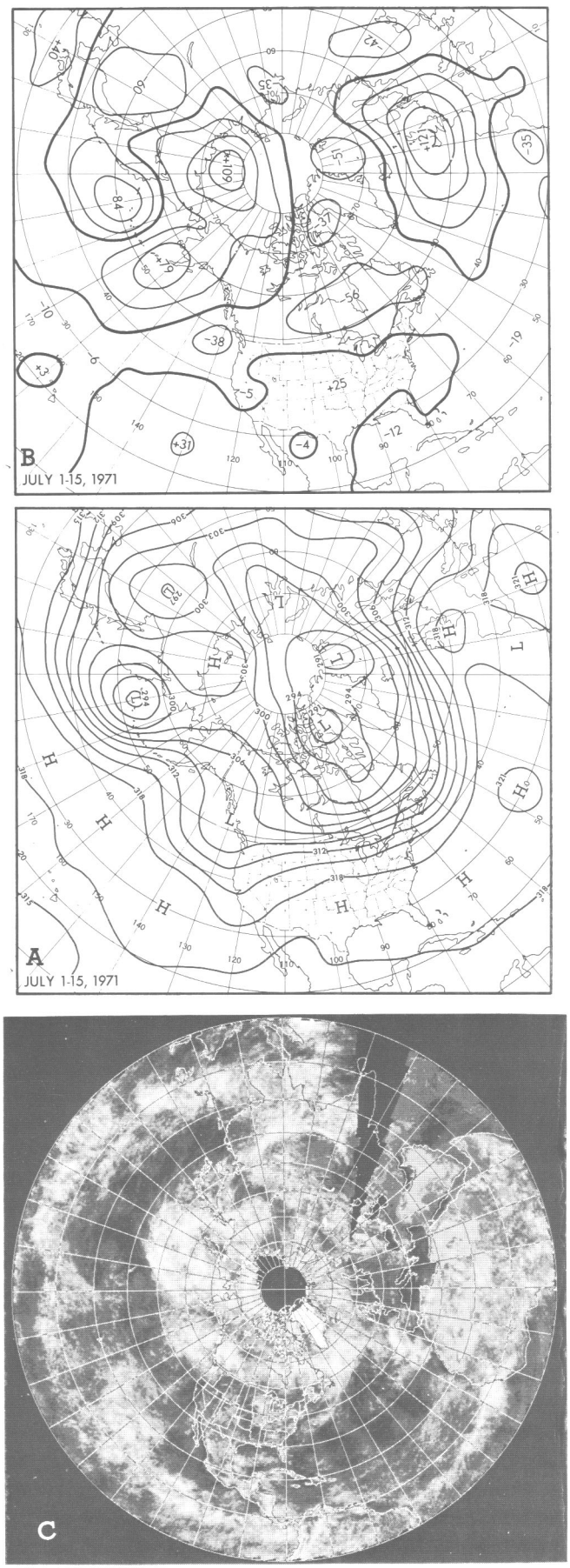

FIGURE 7.—(A) mean 700-mb contours (dam) and (B) departure from normal of mean 700-mb height (m), both for July 1–15, 1971, and (C) composite brightness of the Northern Hemisphere photographed by the NOAA 1 satellite for the period July 8–12, 1971.

northwest and northeast coasts of Greenland (figs. 7A, 7B). Anomalously strong anticyclonic activity over western Europe was heralded by heights 121 m above normal over the British Isles.

The 5-day composite albedo and cloud distribution over the Northern Hemisphere for July 8–12 (fig. 7C) was quite typical of the regime prevailing during most of the first half of the month. Heaviest and most persistent cloudiness was associated with storminess in the northwestern portion of the Pacific, and other cyclones related to the trough off the west coast of North America produced clouds from western Canada and the Gulf of Alaska into the Pacific Northwest. The subtropical high belts in both oceans show as darker, relatively cloud-free areas. Clouds associated with low-latitude typhoon activity are visible across the Philippines into Viet-Nam. The Greenland ice cap and Atlantic intertropical convergence zone also are clearly delineated in the composite photo.

The temperature distribution over the United States during the first full week of July (fig. 8A) was a continuation of that observed in the first few days of the month. The northeastern quadrant and south-central portion of the Nation were warmer than normal, while cool conditions prevailed over the southeastern states and the northwestern third of the country.

The coolness in the Southeast was in part related to extensive precipitation (fig. 8B) whereas the cool temperatures in the Northwest, more typical of late spring, were primarily due to advection of unusually cold air into the area from the Gulf of Alaska (fig. 7A). Several stations reported record low temperatures for July cn the morning of the 7th (table 3).

Precipitation was well distributed over most of the country, with only the southwestern Great Basin, portions of Texas, and isolated areas in the Rocky Mountains and New England remaining rainless.

Seven inches of snow fell at Stampede Pass, Wash., on the 5th and 6th, the most ever to fall there in July. Three inches fell at Paradise Inn at the 5,550-ft level on Mt. Rainier, adding to snow left over from the winter and spring to give a total of 11 ft on the ground, the most snow ever observed so early in the season (considered to begin July 1).

During the second full week of July, the Southwest and Great Basin began to warm rapidly, while cooler weather moved into the northern and eastern portions of the country (fig. 9A). The hottest weather of the month, averaging as much as 9°F above normal for the week, was observed as the 700-mb continental subtropical High began building over the southwest deserts. Several stations reported their hottest temperatures on record (table 3). Two localities reported record or near-record warmth for the whole month (table 1) due to this hot spell and the lack of any appreciable cool weather during July.

Precipitation for the week was generally light in the western half of the country and heavy in the eastern half, similar to the rainfall distribution for the month as a whole (figs. 6, 9B). The northwest border, Texas, and New Mexico were rainless, however. Severe thunderstorms with winds gusting to near hurricane force in parts of Minnesota

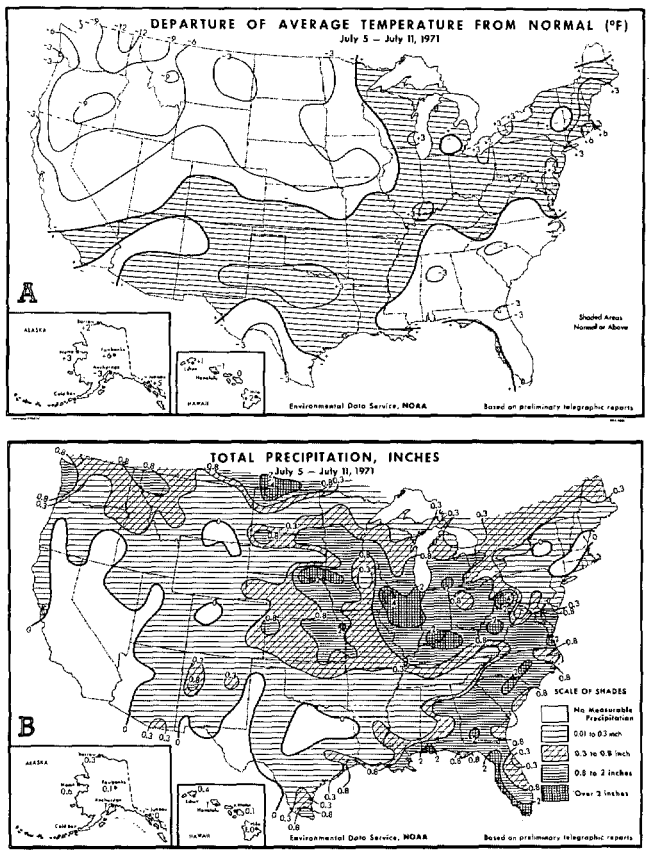

FIGURE 8.—(A) departure from normal of average temperature (°F) and (B) total precipitation (in.) for the week of July 5–11, 1971 (from Environmental Data Service and Statistical Reporting Service 1971).

TABLE 3.—*Record monthly and seasonal temperature extremes observed during July 1971*

Station	Temperature (°F)	Date	Remarks
King Salmon, Alaska	85	22	Highest temperature ever recorded
Pueblo, Colo.	105	11, 12	Highest temperature for July
Winslow, Ariz.	109	13	Highest temperature ever recorded
Grand Junction, Colo.	105	13	Equaled alltime high temperature
Albuquerque, N. Mex.	104	13	Do.
Big Delta, Alaska	32	1	Lowest temperature for July
Great Falls, Mont.	41	3	Do.
Helena, Mont.	36	4	Equaled lowest July temperature
Kalispell, Mont.	31	7	Lowest temperature for July
Missoula, Mont.	31	7	Do.
Astoria, Oreg.	39	7	Do.
Pendleton, Oreg.	42	7	Equaled lowest July temperature
Spokane, Wash.	38	7	Lowest temperature for July
Yakima, Wash.	34	7	Do.
International Falls, Minn.	36	26	Equaled lowest July temperature
Indianapolis, Ind.	54	28	Lowest temperature for July
Sheridan, Wyo.	35	29	Do.
Des Moines, Iowa	47	30	Do.
Dodge City, Kans.	53	30	Equaled lowest July temperature
Kansas City, Mo.	52	30	Lowest temperature for July
Grand Island, Nebr.	42	30	Do.
Norfolk, Nebr.	42	30	Do.
Omaha, Nebr.	45	30	Do.
Valentine, Nebr.	38	30	Do.
Huron, S. Dak.	37	30	Do.
Sioux Falls, S. Dak.	38	30	Equaled lowest July temperature
Fort Smith, Ark.	53	31	Lowest temperature for July
Waterloo, Iowa	43	31	Equaled lowest July temperature
Oklahoma City, Okla.	53	31	Lowest temperature for July
Tulsa, Okla.	51	31	Do.

and Wisconsin contributed to the weekly precipitation total of more than 2 in. there, and another area of heavy showers drenched sections of the southeastern states, producing nearly 5 in. within 24 hr at Meridian, Miss.

5. THE PRONOUNCED MIDMONTH REVERSAL

As mentioned previously, the general circulation over much of the Northern Hemisphere changed markedly shortly before the middle of the month. Heights fell by over 200 m in the western Aleutians from the first half to the second half of the month (fig. 10), as the trough which had been just east of Kamchatka progressed to the central Pacific (fig. 11A). The trough which had been off the Pacific Coast of North America for several weeks (Posey 1971, Stark 1971) was replaced by a strong ridge, with 700-mb heights increasing by over 100 m to as much as 94 m above normal during the last half of July (figs. 10, 11A, 11B).

As a consequence, the trough in eastern North America which had been flat during the first half month amplified considerably during the last half, with heights falling as much as 61 m over the Great Lakes (figs. 7A, 10, 11A). Heights increased over Greenland, the western Atlantic, and western Russia but fell sharply over western Europe by as much as 141 m near Ireland where the anomalously strong ridge of early July was replaced by a trough west of the British Isles.

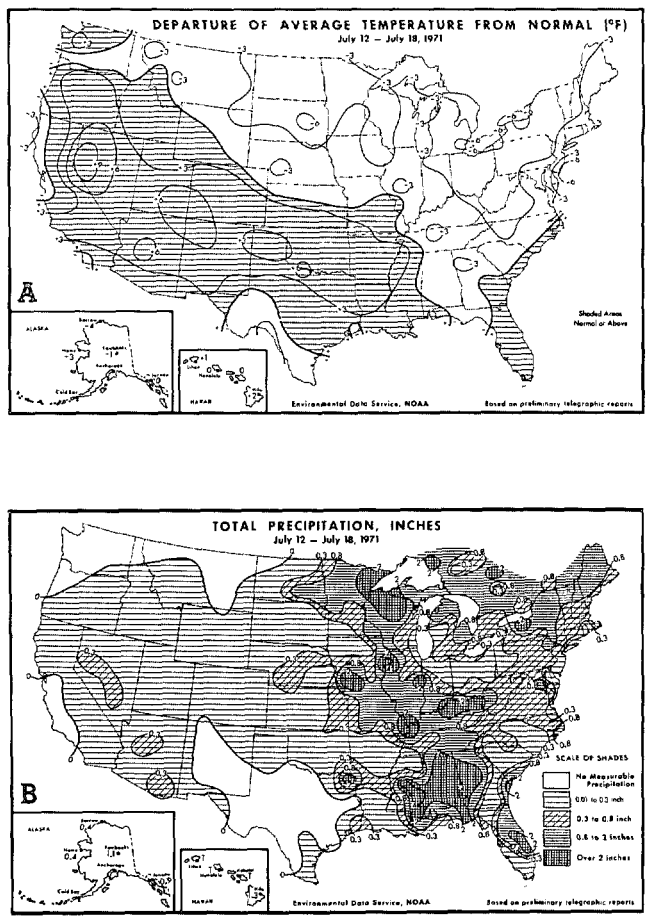

FIGURE 9.—Same as figure 8, for week of July 12–18, 1971.

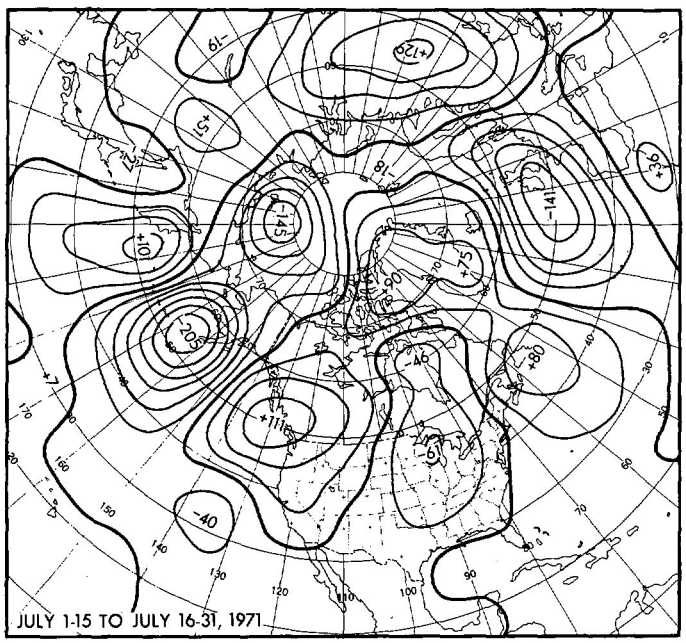

FIGURE 10.—Change in half-monthly mean 700-mb height (m) between July 1–15 and July 16–31, 1971.

The cloud distribution over the Northern Hemisphere for the two selected 5-day periods reflected the change in circulation. Cloudiness increased over the central Pacific as the principal trough progressed to that area. In response to the strong ridging, cloudiness decreased over the eastern part of the Gulf of Alaska and off the Pacific Northwest coast as shown by the marked darkening in those areas (figs. 7C, 11C). The brightness increased off the California coast, as the ridging led to strengthening of the subtropical maritime inversion and a greater incidence of low clouds and fog over the relatively cold water in that area. The cyclonic flow of the first half month (fig. 7A) tended to weaken or break down the inversion, resulting in fewer low clouds then. The air was not cold enough aloft in comparison to the sea-surface temperature to cause an increase in brightness due to deep convective activity, and surface cyclones were few and weak even in the first half of July.

Except for the Pacific Northwest, the average brightness (considered typical of the last half of July) increased over much of the conterminous United States as precipitation became somewhat heavier in most areas toward the end of the month. Cloudiness also increased over western Europe and decreased over western Russia, as might be expected from the circulation changes.

The division of July into two contrasting temperature regimes was particularly sharp in the state of Washington. Temperatures on the first 12 to 14 days were all below normal, and during the remaining days of the month, without exception, were above normal at several stations. The contrast was particularly marked at 4,000-ft high Stampede Pass, where temperatures averaged 8.5°F below normal during the first 12 days and 11.2°F above normal for the remainder of the month. Another example illustrating the extremely sharp nature of the

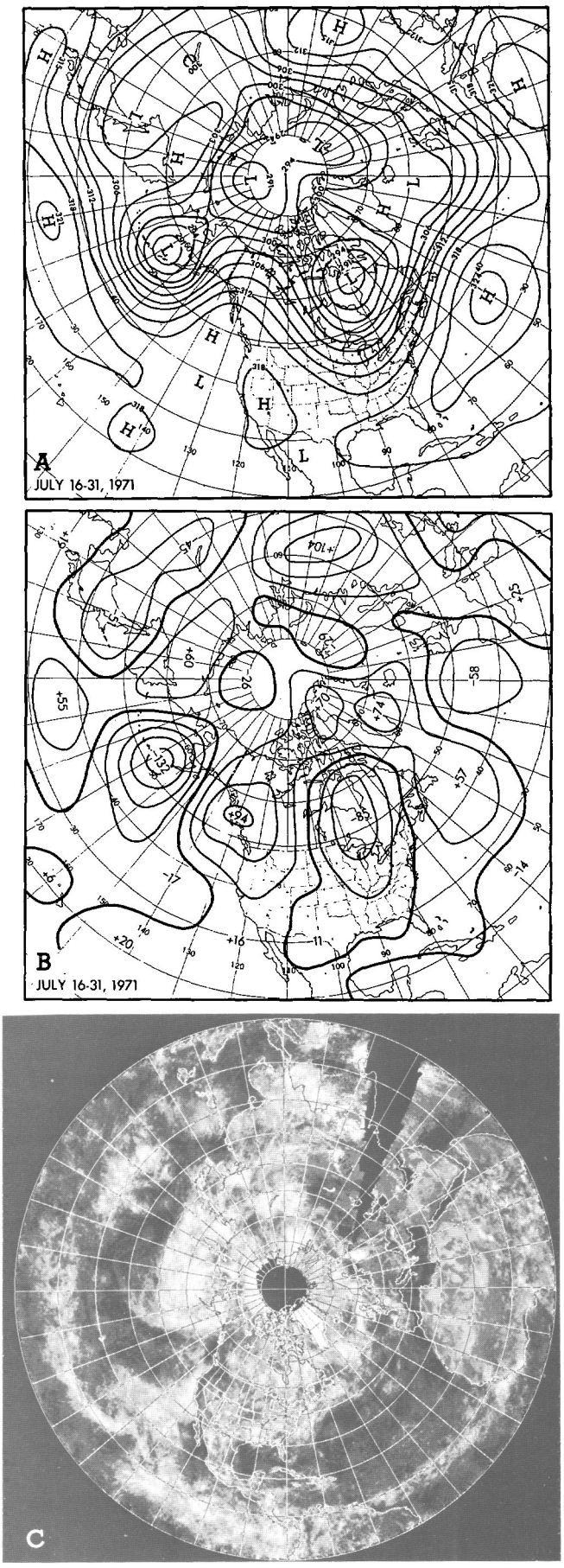

FIGURE 11.—(A) mean 700-mb contours (dam) and (B) departure from normal of mean 700-mb height (m), both for July 16–31, 1971, and (C) composite brightness of the Northern Hemisphere photographed by the ESSA 9 satellite for the period July 23–27, 1971.

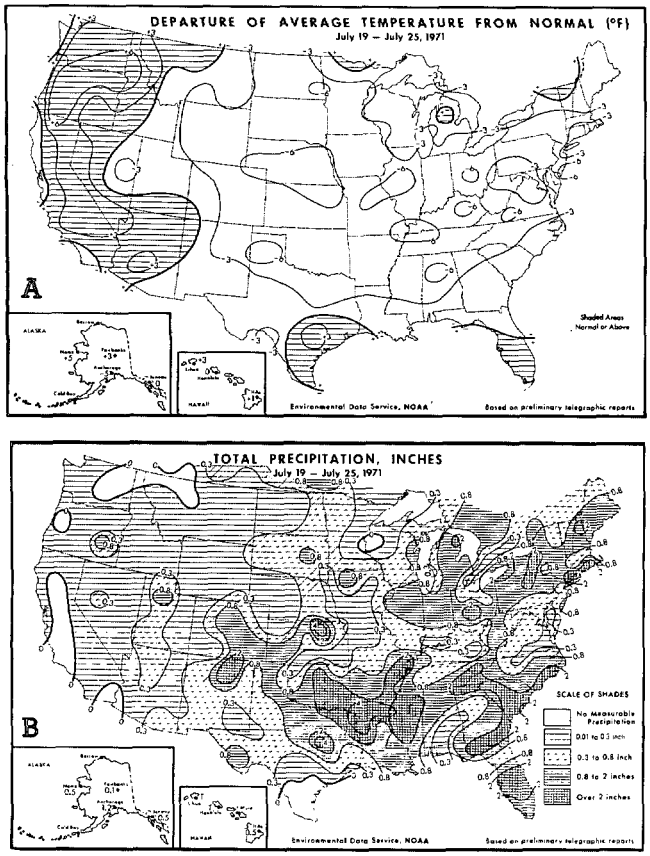

FIGURE 12.—Same as figure 8, for week of July 19–25, 1971.

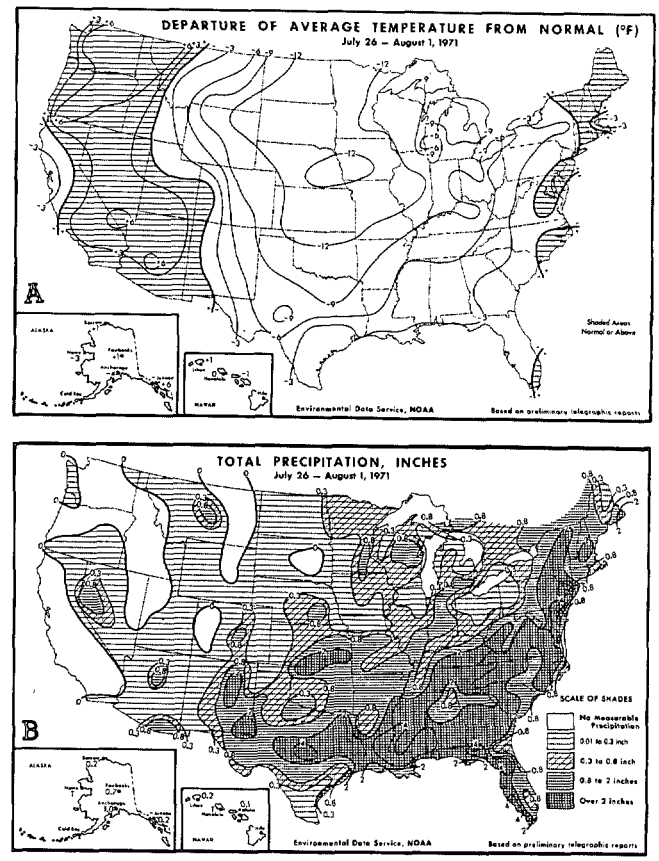

FIGURE 13.—Same as figure 8, for week of July 26–Aug. 1, 1971.

change is shown by the fact that seven new daily records for *low* temperature were set during the first 12 days of July at Yakima, Wash., while four new daily *high* temperature records were established and two equaled during the last half of the month.

Many stations in the middle of the country also reported a reversal of temperature regimes. Here, the first half of the month was somewhat above normal and the last half below. The coolness of the last half was considerably stronger than the earlier warmth in those areas, giving the month a decidedly cool character.

The temperature distribution over the conterminous United States changed little during the last 2 weeks of July, except becoming even more extreme during the last week. Most of the western Great Basin and interior of the Pacific Northwest averaged between 3° and 8°F above normal both weeks (figs. 12A, 13A).

East of the Continental Divide temperatures were more than 3°F below normal except in areas bordering the Gulf of Mexico and in parts of the Northeast. The last week of July was unseasonably cool in the central third of the country, with weekly average temperatures more than 12°F below normal in parts of Nebraska and Iowa (fig. 13A). Several cold Highs which had their origin over the Canadian Arctic traversed the area, leading to damaging frosts in some outlying areas and setting daily records too numerous to list (e.g., on 6 consecutive days from the 25th to the 30th at Rapid City, S. Dak.). Many of these daily records were also the lowest or equaled the lowest temperatures ever recorded in July (table 3).

The incursion of cool air as far south as the Gulf Coast during the last 2 weeks of the month was associated with the outbreak of heavy rains in most of Texas and eastern New Mexico, effectively ending the severe drought in those areas (figs. 12B, 13B). Low-level flow from the east and southeast brought in moisture from the Gulf of Mexico with an upslope component giving added lifting, while a number of weak cutoff Lows aloft stalled in the southern plains area, further destabilizing the air masses and leading to strong convective activity.

Due to the strongly amplified trough in the midwest and the ridge off the East Coast (fig. 11A, 11B), meridional flow from the south was increased and fronts produced heavy showers and thunderstorms as they moved slowly eastward. Bridgeport, Conn., reported 5.95 in. within 24 hr, a new daily record which contributed to a monthly record there (table 2). Much of the South and East from the Appalachian Mountains to the coast reported more than 2 in. of precipitation during the last week of July (fig. 13B).

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